Report To Congress

The Satellite Home Viewer Extension And Reauthorization Act Of 2004

Study Of Digital Television Field Strength Standards And Testing Procedures

ET Docket No. 05-182

Adopted: December 6, 2005 **Released: December 9, 2005**

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ACKNOWLEDGEMENTS

This Report was prepared under the leadership of the Office of Engineering and Technology, in cooperation with the Media Bureau.

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I. SUMMARY

1. Section 204(b) of the Satellite Home Viewer Extension and Reauthorization Act of 2004 (SHVERA) requires that the Federal Communication Commission (Commission) conduct an inquiry and develop recommendations regarding whether the Commission's digital signal strength standard and the signal testing procedures used to identify if a household is "unserved" for purposes of the satellite statutory copyright license for distant digital signals should be revised.[1] This Report is in fulfillment of Congress' directives to the Commission in Section 204(b) of the SHVERA.

2. Consistent with the SHVERA Section 204(b) directives, the Report describes the results of the Commission's study and *Inquiry* on this matter and the Commission's findings regarding whether changes should be made to the statutes or the Commission's rules. As set forth in detail below, the Commission specifically finds that:

- No specific changes are needed to the digital television field strength standards and/or planning factors for purposes of determining whether a household is eligible to receive retransmitted distant network television signals.
- The Commission should conduct a rule making proceeding to specify procedures for measuring the field strength of digital television signals at individual locations that are generally similar to the current procedures for measuring the field strength of analog television stations. Certain modifications to those procedures are needed, however, to address differences in analog and digital television signals. The proper procedures for measuring digital television signals would be developed through the recommended rule making proceeding.
- The existing improved Individual Location Longley-Rice (ILLR) model should be used for predicting whether a household is unserved by digital television signals. The Commission specifically recommends that Congress amend the copyright law, as well as the Communications Act, to allow a predictive model to be used in connection with eligibility for a distant digital signal. The Commission further recommends that Congress provide the Commission with authority to adopt the existing improved ILLR model as a predictive method for determining households that are unserved by local digital signals for purposes of establishing eligibility to receive retransmitted distant network signals under the SHVERA.

The Report also includes a study of digital television receiver performance, attached hereto as Appendix C, that, *inter alia*, finds that there is no relationship between the ability of currently available digital television receivers' to receive over-the-air signals and the prices of those receivers.

II. BACKGROUND

3. Broadcast television stations have rights, under the Copyright Act[2] and private contracts, to control the distribution of the national and local programming that they transmit. In 1988, Congress adopted the Satellite Home Viewer Act (SHVA) as an amendment to the Copyright Act in order to protect the broadcasters' interests in their programming while simultaneously enabling satellite carriers to provide broadcast programming to those satellite subscribers who are unable to obtain broadcast network programming over the air. Under the SHVA, these subscribers were generally considered to be

[1] *See* The Satellite Home Viewer Extension and Reauthorization Act of 2004, Pub. L. No. 108-447, § 207, 118 Stat 2809, 3393 (2004) (codified at 47 U.S.C. § 339(c)). The SHVERA was enacted as title IX of the "Consolidated Appropriations Act, 2005." Hereinafter Section 204(b) is cited as codified in 47 U.S.C. 339(c).

[2] 17 U.S.C. § 119.

"unserved" by their local stations. In the SHVA, Congress linked the definition of "unserved households" to a Commission-defined measure of analog television signal strength known as "Grade B intensity."[3] The Grade B signal intensity standard, as set forth in Section 73.683(a) of the Commission's rules, is used to identify a geographic contour that defines an analog television station's service area.[4] For digital television stations, the counterpart to the Grade B signal intensity standards for analog television stations are the values set forth in Section 73.622(e) of the Commission's Rules describing the DTV noise-limited service contour.[5]

4. The new Section 339 requires the Commission to conduct an inquiry regarding whether, for purposes of identifying if a household is unserved by a digital signal under Section 119(d)(10) of Title 17, United States Code, the digital signal strength standards in Section 73.622(e)(1) of the Commission's rules, or the testing procedures in Section 73.686(d) of the Commission's rules, should be revised to take into account the types of antennas that are available to consumers.[6] In 1999, the Commission adopted a *Report and Order* (*SHVA Report and* Order) addressing three major issues that arose in the context of the SHVA and several pending court actions and petitions to the Commission.[7] First, it affirmed the existing definition of a signal of Grade B intensity for use in determining eligibility for reception of distant network signals. Second, the Commission adopted rules for determining whether a household is able to receive an analog television signal of this strength.[8] In particular, the Commission adopted rules establishing a standardized method for measuring the strength of analog television signals on-site at individual locations. And finally, it endorsed a method for predicting the strength of such signals that could be used in place of actually taking measurements.[9]

5. As added under the Satellite Home Viewer Improvement Act of 1999 (SHVIA),[11] the then-new Section 339(c)(3) of the Communications Act required that the Commission develop and prescribe by rule a point-to-point predictive model for reliably and presumptively determining the ability of individual locations to receive signals in accordance with the signal intensity standard in effect under Section 119(d)(10)(A) of Title 17 of the Unites States Code, that is, the Grade B standards.[12] Section 339(c)(3) further required that the Commission rely on the ILLR model which the Commission had earlier developed for such predictions and that the Commission ensure that such model takes into account

[3] See 17 U.S.C. § 119(d)(10)(A); 47 C.F.R. § 73.683(a).

[4] 47 C.F.R. § 73.683(a); *see also* 47 C.F.R. § 73.684.

[5] 47 CFR § 73.622(e); *see* also 47 CFR § 73.625(b) (determining coverage). As set forth in Section 73.622(e), a station's DTV service area is defined as the area within its noise-limited contour where its signal strength is predicted to exceed the noise-limited service level.

[6] 47 U.S.C. § 119(d)(10); 47 C.F.R. § 73.622(e)(1); 47 C.F.R. § 73.686(d).

[7] Satellite Delivery of Network Signals to Unserved Households for Purposes of the Satellite Home Viewer Act, CS Docket No. 98-201, *Report and Order*, 14 FCC Rcd 2654, 2655 at ¶ 2 (1999) (*SHVA Report and Order*); *Order on Reconsideration*, 14 FCC Rcd 17373 (1999).

[8] *SHVA Report and Order*, 14 FCC Rcd at 2656 ¶ 4.

[9] *SHVA Report and Order*, 14 FCC Rcd at 2657 ¶ 8.

[11] *See* Consolidated Appropriations Act for 2000, Pub. L. 106-113, § 1000(9), 113 Stat. 1501 (enacting S. 1948, including the Satellite Home Viewer Improvement Act of 1999, Title I of the Intellectual Property and Communications Omnibus Reform Act of 1999, relating to copyright licensing and carriage of broadcast signals by satellite carriers, codified in scattered sections of 17 and 47 U.S.C.). Section 1008(a) of SHVIA added, *inter alia*, new Section 339 ("Carriage of Distant Television Stations by Satellite Carriers") to the Communications Act of 1934, 47 U.S.C. § 151 *et seq.*

[12] *See also* 47 C.F.R. § 73.683(a) (Grade B field strength contours for channels 2-6, 7-13, and 14-69).

terrain, building structure, and other land cover variations. In response to these provisions, the Commission adopted a *First Report and Order* in May 2000 in which it amended its rules to prescribe use of an improved point-to-point ILLR model for establishing whether individual households are eligible to receive distant analog network television signals.[13] This model includes adjustments for land use and land cover loss values. The rules also provide for a neutral and independent entity to evaluate the qualifications of potential testers to conduct on-site signal strength measurements in cases where a network television station denies a subscriber's request for a waiver of the ILLR prediction that the viewer is "served."

6. In addition, in the SHVIA Congress directed the Commission to conduct an inquiry and prepare a report regarding the broadcast TV signal strength standard used for satellite carrier purposes. The then-new Section 339(c)(1) of the Communications Act required that this investigation evaluate all possible standards and factors for determining eligibility to receive retransmitted network station signals and, if appropriate, recommend modification of, or alternative standards or factors, to the Grade B intensity standard for analog television signals and to make a further recommendation relating to an appropriate standard for digital television signals.[14] In response to this directive, the Commission inquired into and evaluated the possible standards and factors for determining eligibility of households to receive retransmissions of network station signals by satellite carriers. It specifically considered whether to recommend modifications to, or alternative standards or factors for, the Grade B intensity standard for analog television signals. On November 29, 2000, the Commission issued a *Report to Congress* (*SHVIA Report*) in which it recommended retention of the Grade B signal intensity standard and eight of the nine planning factors used in developing that standard as the basis for predicting whether a household is eligible to receive retransmitted distant TV network analog signals under the SHVIA.[15] The Commission recommended modification of the remaining planning factor (time fading) by replacing the existing fixed values with location-dependent values determined for the actual receiving locations using the Individual Location Longley-Rice (ILLR) prediction model. With regard to digital signals, the Commission found that it would be premature to construct a distant network signal eligibility standard for DTV signals at that time. The Commission therefore recommended that establishment of a distant network signal eligibility standard for digital signals be deferred until such time as more substantial DTV penetration is achieved and more experience is gained with DTV operation.[16]

7. In December 2004, Congress enacted the SHVERA, which revised the statutory provisions of the SHVA and SHVIA, including Section 339 of the Communications Act of 1934.[17] Under the

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[13] *See* In the Matter of Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations, *First Report and Order* in ET Docket No. 00-11 (*ILLR First Report and Order*), 15 FCC Rcd 12118 (2000); recon. *Memorandum Opinion and Order* in ET Docket No. 00-11, 19 FCC Rcd 9963 (2004); appeal pending, EchoStar L.L.C. v. FCC & USA, No. 04-1304 (D.C. Circuit).

[14] *See* 47 U.S.C. § 339(c). *See also* 17 U.S.C. § 119(a)(2)(b) and (d)(10). Section 339(c) sets forth the circumstances in which Direct Broadcast Satellite (DBS) subscribers are eligible to receive retransmission of distant network signals. *See also* 47 U.S.C. 339(c)(1) *as amended by* the SHVERA.

[15] *See Report to Congress, In the Matter of Technical Standards for Determining Eligibility for Satellite Delivered Network Signals Pursuant to the Satellite Home Viewer Improvement Act,* 15 FCC Rcd 24321 (2000). The eight planning factors recommended for retention were: thermal noise, transmission line loss, receiving antenna gain, dipole factor, terrain factor, urban noise, signal-to-noise ratio, and urban noise. The development of the Grade B signal intensity standard and its use in connection with the authorization of analog television stations and the determination of stations' service areas and contours is also discussed in greater detail in the *SHVIA Report*.

[16] *Id.*

[17] 47 U.S.C. § 339.

SHVERA, viewers in individual households who are not able to receive network digital television signals over-the-air from local television stations and who are in circumstances that meet certain additional qualifying criteria are eligible to receive those digital network television signals from distant stations carried via satellite. It is therefore important that the standard for determining whether a local digital television station's signal strength at a specific location is sufficient for reception of service and that the procedures for evaluating digital television signal strength provide an accurate means for determining whether a household can receive a local network station's digital signal. Subsection 339(a)(2)(D)(vi), as revised by SHVERA, provides that the digital signal strength standard defined in Section 73.622(e) of the Commission's rules shall serve as the basis for determining whether a satellite TV subscriber is eligible to receive retransmitted distant TV network digital signals.[18] Section 73.622(e)(1) provides that the service area of a DTV station is the geographic area within the station's noise-limited F(50, 90) contour where its signal is predicted to exceed the noise-limited service level.[19] Within this contour, service is considered available at locations where the station's signal strength, as predicted using the terrain dependent Longley-Rice point-to-point propagation model, exceeds the following noise-limited service levels:[20]

Channels 2-6 (low-VHF)..28 dBu
Channels 7-13 (high-VHF).....................................36 dBu
Channels 14-69 (UHF)...41 dBu

8. Subsection 339(c)(1), as revised by the SHVERA, requires the Commission, not later than December 8, 2005, to complete an inquiry and submit a report recommending whether, for purposes of identifying if a household is unserved by an adequate digital signal, the digital signal strength standard set forth in Section 73.622(e)(1) of the Commission's Rules or the testing procedures in Section 73.686(d) of the Commission's Rules should be revised to take into account the types of antennas that are available to consumers.[21] Subsection 339(c)(1) requires that, in conducting the required study, the Commission consider six specific issues relating to the question of digital signal strength in the context of the "unserved household":[22]

- Whether to account for the fact that an antenna can be mounted on a roof or placed in a home and can be fixed or capable of rotating;
- Whether the Commission's rules should be amended to create different procedures for determining if the requisite digital signal strength is present than for determining if the requisite analog signal strength is present;

[18] 47 U.S.C. § 339(a)(2)(D)(vi).

[19] *See* Section 73.622(e)(1) of the Commission's Rules, 47 C.F.R. § 73.622(e)(1). The F(50, 90) contour describes the outer edge of a geographic area in which a transmitter's signal strength is predicted to exceed the field strength standard at 50 percent of the locations 90 percent of the time.

[20] *See* Section 73.622(e) (1) and (2) of the Commission's Rules, 47 C.F.R. § 73.622(e) (1), (2). Guidance for evaluating digital television station coverage areas using the Longley-Rice methodology is provided in OET Bulletin No. 69, *see* OET Bulletin No. 69, "Longley-Rice Methodology for Evaluating TV Coverage and Interference" (July 2, 1997). OET Bulletin No. 69 is available on the Commission's website at http://www.fcc.gov/oet/info/documents/bulletins/.

[21] 47 U.S.C. § 339(c)(1). The report is to be submitted to the Committee on Energy and Commerce of the House of Representatives and to the Committee on Commerce, Science, and Transportation of the Senate. The report is to contain recommendations, if any, as to what changes should be made to Federal statues or regulations. See 47 U.S.C. § 339(c)(1)(C).

[22] 47 U.S.C. 339(c)(1)(B)(i)-(vi), *as amended by* Section 204(b) of the SHVERA. The complete text of the new Section 339(c)(1) is set forth in Appendix A.

- Whether a standard should be used other than the presence of a signal of a certain strength to ensure that a household can receive a high-quality picture using antennas of reasonable cost and ease of installation;
- Whether to develop a predictive methodology for determining whether a household is unserved by an adequate digital signal;
- Whether there is a wide variation in the ability of reasonably priced consumer digital television sets to receive over-the-air signals, such that at a given signal strength some may be able to display high-quality pictures while others cannot, whether such variation is related to the price of the television set, and whether such variation should be factored into setting a standard for determining whether a household is unserved by an adequate digital signal; and
- Whether to account for factors such as building loss, external interference sources, or undesired signals from both digital television and analog television stations using either the same or adjacent channels in nearby markets, foliage, and man-made clutter.

The above specifications for study address three separate but interrelated concerns: 1) the appropriateness of the DTV planning factors that underlie the DTV signal strength standard, 2) the appropriateness of the objective test-site methodology for measuring digital signals, and 3) whether a predictive model should be developed for determining whether a household is unserved by an adequate digital TV signal for purposes of eligibility to receive distant network TV signals.

9. On April 29, 2005, the Commission initiated an inquiry to gather information pursuant to Section 339(c)(1).[23] The Commission received 9 comments and 5 reply comments in response to its *Notice of Inquiry* (*Inquiry*) in this proceeding. The results of the Commission's study and analysis of the record of its *Inquiry* and other research and information in this matter and its recommendations are described in the following sections of this Report. These sections address the digital signal strength standards, testing procedures, and predictive models and specifically include consideration of the six issues that Congress specifically asked the Commission to address in Section 204 of the SHVERA.

[23] In the Matter Of Technical Standards For Determining Eligibility For Satellite-Delivered Network Signals Pursuant To The Satellite Home Viewer Extension and Reauthorization Act, ET Docket No. 05-182, *Notice of Inquiry (Inquiry)*, 20 FCC Rcd. 9349 (2005).

III. THE DIGITAL TV SIGNAL STRENGTH STANDARDS

10. Eligibility to receive distant network signals retransmitted by a satellite carrier has been, in principle, based on the inability of a household subscribing to a Direct Broadcast Satellite (DBS) service is not able to receive network signals over-the-air at its location using a receiving system that conforms to the assumed receiving system on which the television service area standards are based.[24] If a household is not able to receive a network signal at a field strength level equal to or greater than the TV service area Grade B (analog TV) or noise-limited (digital TV) standards, that household may be eligible to receive the signal of a distant station affiliated with that network that is retransmitted on the household's DBS service if it meets other criteria for eligibility. Congress has asked the Commission to investigate whether the noise-limited DTV service standard should be revised to take into account the types of antennas that are available to consumers. In considering this issue, the Commission must consider: 1) whether to account for the fact that an antenna can be mounted on a roof or placed in a home and can be fixed or capable of rotating, 2) whether there is a wide variation in the ability of reasonable priced consumer digital television sets to receive over-the-air signals such that at a given signal strength some may be able to display high-quality pictures while others may not, whether such variation is related to the price of the television set, and whether such variation should be factored into setting a standard for determining whether a household is unserved by an adequate digital signal, and 3) whether to account for factors such as building loss, external interference sources, or undesired signals from both digital television and analog television stations using either the same or adjacent channels in nearby markets, foliage, and man-made clutter. In this section, we discuss the digital TV signal strength standards and evaluate the factors underlying those standards, including those specified in Section 204, in light of our *Inquiry* and study. We also consider whether any adjustments to those standards are warranted in light of our findings.

A. The DTV Service Area Field Strength Intensity Standards

11. As indicated above, the service areas of broadcast television stations, in the absence of interference, are defined on the basis of a concept known as "noise-limited" service. Under this concept, a TV station's service extends to cover geographic locations out to the edge of where reception is no longer possible because of interference from background electrical noise. The background noise limiting reception of service arises both from the environment and from within the equipment used to receive service. Both the analog TV Grade B field strength intensity standards and the digital TV noise-limited field strength intensity standards are defined on this basis. These standards were developed in the early days of both methods of television modulation as a key component of the Commission's television station channel allotment and service area regulations.[25] The DTV service area definitions further specify that service is considered to be present in areas within the noise-limited contour where signal strength is

[24] The criteria for eligibility to receive a distant network signal from a DBS service also include factors in addition to the ability of a household to receive that network signal over-the-air from a local TV station, *see* Section 339 of the Communications Act, 47 U.S.C. § 339.

[25] *See* Television Broadcast Service, *Third Notice of Further Proposed Rule Making*, Appendix B, 16 Fed. Reg. 3072, 3080 (April 7, 1951), adopted in Amendment of Section 3.606 of the Commission's Rules and Regulations and Amendment of the Commission's Rules, Regulations, and Engineering Standards Concerning the Television Broadcast Service in the Band 470 to 890 MHz for Television Broadcasting, *Sixth Report and Order*, 41 FCC 148 (1952); *see also* Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, *Sixth Report and Order* in MM Docket No. 87-268, 12 FCC Rcd 14588 (1997) (*DTV Sixth Report and Order*), at ¶¶183-196.

predicted to exceed the noise-limited signal level using the terrain-dependent Longley-Rice point-to-point propagation model.[26]

12. The field strength of television signals decreases with distance from the transmitter and varies across individual locations and time. At locations close to a station's transmitter the variation of signal strength across time and location are generally not great. However, as distance increases, the variability of the available signal strength with both location and time increases significantly. At the edge of a station's service area, its signal will be available in some locations more of the time than at others. Historically, if service is not available all, or most of the time, it is simply considered not available. Under both the analog Grade B and digital noise-limited F(50,90) service standards, an acceptable television picture and sound service is available at 50% of the locations for 90% of the time at locations on the outer edge of a station's service area. The signal strength values of the analog TV standards were selected to provide service at these levels of availability and the digital television standards were specified to enable DTV stations to replicate their analog service.[27]

13. The noise-limited digital TV field strength standards were derived from a set of assumptions for the several technical planning factors that are present in a typical DTV receiving system and for a defined level of service. The DTV receiving system includes all elements in the electrical path from the point where a DTV signal is converted from electromagnetic energy to electric energy at the receive antenna to the point in the tuning function of a TV set where the received signal is delivered to the demodulator that produces the 19.39 mbps digital TV bitstream. The effect of each of the elements in the receiving system and the factors for time and location variability are summed to determine the minimum signal level that must be available over-the-air to provide an F(50,90) level of service at the edge of a station's noise-limited service area contour. These factors and their assumed values as used in establishing the DTV noise-limited service area field strength intensity standards are:[28]

[26] Guidance for evaluating DTV coverage areas using the Longley-Rice methodology is provided in *OET Bulletin No. 69*, which is available through the Internet at the Commission's website, http://www.fcc.gov/oet/info/documents/bulletins/.

[27] *See DTV Sixth Report and Order, supra* note 25, at ¶¶ 29-33 and Appendix B.

[28] *See DTV Sixth Report and Order, supra* note 25, at Appendix A.

Planning Factor:	Symbol	Low VHF (2-6)	High VHF (7-13)	UHF (14-69)
Geometric Mean Frequency (MHz)	F	69	194	615
Dipole Factor (dBm-dBu)	K_d	-111.8	-120.8	-130.8
Thermal Noise (dBm)	N_t	-106.2	-106.2	-106.2
Antenna Gain (dB)	G	4 *	6 *	10 *
Front-to-back ratio (dB) (ratio of forward gain to maximum response over rear 180°)	FB	10	12	14
Downlead line loss (for 50 ft/15 m. of coaxial cable (dB)	L	1	2	4
System (receiver) noise figure (dB)	N_s	10	10	7
Required receiver S/N ratio (dB)	S/N	15.2**	15.2**	15.2**
Time variability factor (90% availability) (dB)	dT	0***	0***	0***
Location variability factor (50% availability) (db)	dL	0	0	0

* Antenna placement is assumed outdoors at 9 meters (30 feet).

** The required S/N value stated in the *DTV Sixth Report and Order* and OET Bulleting No. 69 is 15. That value was rounded from the 15.19 value set forth in the FCC Advisory Committee on Advanced Television Service's (ACATS) *Final Technical Report* (October 31, 1995) at Table 5.1.

*** The time variability factor is defined as the difference between the F(50,10) minus F(50,50), where these two values are determined from the charts in Section 73.699 of the Commission's rules, 47 C.F.R. § 73.699. This factor is a function of the distance between the transmitting and receiving antennas.

14. Using the factors in the above chart, the minimum signal level that needs to be present at the input terminal of a television receiver, to provide service is the sum of the thermal noise, the receiver noise figure, and the receiver signal-to-noise (S/N) ratio, that is:

Minimum receiver signal level	$R = N_t + N_s + S/N$	
for low and high VHF channels	$= -106.2 + 10 + 15.2 =$	-81.0 dBm
for UHF channels	$= -106.2 + 7 + 15.2 =$	-84.0 dBm

15. Considering the entire receiving system, the minimum field strength needed to be available at the antenna is the sum of the minimum signal level needed at the receiver, the downlead line loss, and the dipole factor, less the antenna gain:

Minimum field strength to receive service	$MFS = R + L + K_d - G$	
for low VHF channels	$= -81.0$ dBm $+ 1 + 111.8 - 4$	$= 27.8$ dBμV/m
for high VHF channels	$= -81.0$ dBm $+ 2 + 120.8 - 6$	$= 35.8$ dBμV/m
for UHF channels	$= -84.0$ dBm $+ 4 + 130.8 - 10$	$= 40.8$ dBμV/m

16. Rounding to the nearest decibel, we have 28, 36, and 41 dBu as the minimum field strength standards for channels in the low VHF, high VHF, and UHF channel bands, respectively. As indicated in the chart of planning factors, above, no adjustments were needed to compensate for time or location variability beyond that already afforded by F(50, 90) level of service.

B. Review of the DTV Field Strength Intensity Standards

17. Several parties commenting in the *Inquiry* indicate that the Commission should continue to determine whether a household is unserved based on the current assumed planning factors, which include an assumption that an outdoor stationary antenna is mounted at a height of 9 meters.[29] The National Association of Broadcasters (NAB) states the assumptions made in the Commission's DTV planning factors and in the Longley-Rice model about household reception equipment are reasonable and realistic.[30] In particular, NAB asserts that, as was the case for analog television, the Commission's digital transition proceeding has always assumed that consumers in fringe areas would use rooftop antennas that are properly oriented to achieve the best reception from the station in question.[31] As a consequence, NAB reasons that broadcasters have built transmission systems based on these Commission assumptions and standards and, thus, it would now be unfair to assume, as a DTV planning factor, that viewers will use indoor antennas.[32] Also, NAB contends that, because rooftop antennas provide much better service than indoor antennas, households have long used rooftop antennas to achieve over-the-air reception, particularly if the household is at some distance from the transmitting tower. It notes that rural households often rely on small towers – with over-the-air antennas placed considerably higher than the assumed rooftop level – to receive a strong signal from stations several dozen miles away.[33] Additionally, NAB asserts that satellite dish antennas can only be used outdoors, usually atop a roof, and, therefore, it would be "egregiously discriminatory" for the Commission to conclude that while satellite subscribers are expected to rely on a rooftop antenna for their satellite reception, they cannot be expected to do the same to pick up over-the-air signals.[34] The Consumer Electronics Association (CEA) submits that broadcast television households should have a right to a consistent definition of whether their households are considered served by a TV station.[35]

18. In their comments, the ABC, CBS, and NBC Television Affiliate Association (Network Affiliates) state that the Commission's DTV planning factors established appropriate signal strength thresholds for reception of real-world DTV signals.[36] These planning factors, Network Affiliates assert, contain a "safety margin" to ensure that quality DTV reception is achievable precisely where the

[29] The Association for Maximum Service Television, Inc. (MSTV) comments at 2 (Commission should reaffirm the DTV signal strength standards for determining DTV service availability and for identifying underserved households pursuant to SHVERA); Consumer Electronics Association (CEA) comments at 3 (although antenna type and placement is a critical factor in DTV reception, it should not be considered in determining household eligibility for distant DTV network signal reception; instead, such eligibility should be determined based on the failure of a signal of at least a given field strength to be present at a specified height above the location); NAB comments, *passim;* and Network Affiliates comments, *passim.*

[30] NAB comments at 16.

[31] *Id.* at 14 and 18-20. NAB points out that, in comparison to outdoor antennas, indoor antennas do not perform as well at receiving over-the-air TV signals, have lower gain, are placed in inferior locations for over-the-air reception, are typically nondirectional, and are affected by the movement of people within the room. *Id.* at 16-17.

[32] *Id.* at 18-19.

[33] Id. at 17.

[34] *Id.* at 18.

[35] *See* CEA comments at 2.

[36] Network Affiliates comments at 13-38.

Commission expects it to be, namely, in the replicated analog TV service area.[37] With these considerations in mind, and realizing that satellite antennas must be mounted outdoors and must be oriented to the satellite for proper reception, the Network Affiliates contend that it would be "inappropriate to essentially penalize" local TV stations for those consumers who were only willing to install an indoor antenna (or an antenna that was incapable of being oriented to the desired signal), especially when those consumers are willing to take additional, necessary steps to obtain adequate satellite reception.[38] Moreover, they state that real-world equipment, including fifth generation DTV receivers whose performance in terms of whether they are able to receive service does not vary by price, demonstrates that the Commission's current signal strength thresholds are more than adequate to receive a high-quality digital picture.[39] The MSTV, the NAB and the Network Affiliates argue that there is no need for the Commission to consider modifying the inherent assumptions regarding DTV antenna receiving systems in the DTV planning factors and that it should recommend to Congress that the DTV signal strength standards remain the same for purposes of determining whether a household is "unserved" by a digital signal for purposes of 17 U.S.C. § 119(d)(10).[40] CEA argues that it is not appropriate for the Commission to take into consideration that an antenna can be mounted on a roof or placed inside a home or can be fixed or capable of rotating. It submits rather that it is necessary and sufficient for the Commission to state that a given field strength, predicted or measured, at a known height above the location determines whether a household is served.[41]

19. Other commenting parties assert that the planning factors should be substantially modified or are otherwise insufficient for use in determining household eligibility pursuant to SHVERA.[42] EchoStar argues that the signal strength standard should be revised to account for DTV receiver performance, man-made noise, indoor antenna use, and the lack of rotation in outdoor antennas.[43] It submits that the signal sensitivities of the current generation of receivers are worse than the signal sensitivities assumed in the DTV planning factors and that as a result many consumer DTV sets may not be able to display a DTV picture even when the signal strength meets the Commission's standards. EchoStar also argues that for the low VHF channels man-made noise was not adequately taken into account in the planning factors and that as a result the Commission did not build in a sufficient margin for noise when it set the signal strength standard for those channels. With regard to indoor antenna, EchoStar argues that an outdoor antenna is not practical for many households, particularly those located in apartment buildings. It further contends that even households with outdoor antennas often do not have rotating antennas or have a practical means of re-pointing their antennas "on the fly" to achieve optimum reception for every broadcast station in the market. EchoStar suggests that the Commission should take these factors into account and recommend modifications to the signal strength standard.

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[37] *Id.* at 15-33.

[38] *Id.* at 34.

[39] *Id.* at 35.

[40] MSTV comments at 2; NAB comments at 16-25; Network Affiliates comments at 13-15 and 37-38.

[41] CEA comments at 3.

[42] EchoStar comments at 4 and 6; Robinson Telephone comments, *passim*; and Viamorph, Inc. comments, *passim* (predictive model should include methods to account for variations in antenna performance, including receiving antenna characteristics and detailed geographical, botanical, atmospheric and other data; Viamorph states that it is introducing a new "digital smart antenna" technology into the consumer marketplace).

[43] EchoStar comments at 4 and 6.

20. In the subsections below we examine the signal strength questions addressed in the SHVERA and other planning factor issues raised in the *Inquiry*. We will consider the comments above and our evaluations of the issues in these subsections in developing our recommendations to Congress on DTV signal strength standards, which are set forth at the end of this section.

1. Antenna Gain, Orientation, and Placement

21. An antenna is the first element in the path that constitutes a household's TV receiving system. The antenna receives the electromagnetic energy of a television signal and converts it into electrical energy. The effectiveness of receiving antennas is determined both by factors intrinsic to the specific antenna design and by external factors. With regard to the former, antennas are designed with varying amounts of antenna gain or directivity. The greater the gain of a receiving antenna is, the greater the antenna's ability to capture weak signals. However, there is a significant tradeoff when incorporating additional gain in an antenna design. That is, designing an antenna with greater gain requires that it also be designed to have a narrower beamwidth. Beamwidth, in turn, refers to the antenna's angle of orientation within which the gain occurs. The narrower the beamwidth of a receiving antenna, the more critical it is to accurately aim the antenna directly at the source of the signal of interest. The signal strength of a transmission that is received by an antenna's main lobe beamwidth will be stronger than if that transmission was received from a direction outside that main lobe. With regard to external factors, considerations relating to antenna placement and orientation affect the ability of a household to receive an adequate DTV signal. For example, because structures located within the line of sight between the transmitter and the receiving antenna can block or weaken the strength of received signals, an outdoor antenna installation, such as upon a rooftop, will generally allow a stronger signal to be received by the antenna than will an indoor antenna installation. Thus, for households located in the same general area, an indoor antenna will generally need an antenna with greater gain than will a household in which the antenna is placed outdoors. If an antenna is oriented/directed so that its maximum gain is not focused on the desired TV signal, the received energy from that station's signal will be much lower.

22. Inherent in the Commission's definition of digital television service area are certain assumptions regarding the receiving antenna. For DTV, the Commission assumes that the receiving antenna is located outdoors at a height of 9 meters above ground.[44] In addition, the Commission's procedures for evaluating DTV service areas set forth specific values for antenna gain that depend upon the specific DTV channel band, namely, 4 dB for low VHF, 6 dB for high VHF, and 10 dB for UHF and assume that the antenna is oriented in the direction which maximizes the values of the field strength received for the signal being measured.[45]

23. In the *Inquiry*, we sought comment and information regarding the antenna equipment available to and used by consumers as a possible factor in the DTV signal availability standards. Consistent with the provisions of Section 339(c)(1)(B)(*i*), we asked whether there is a need to revise the standards by which adequate DTV network signals are deemed available to households in order to account for the facts that DTV antennas can be mounted on a roof or within a home and can be installed in a fixed position or in a mounting that allows them to be rotated. As required under Section 339(c)(1)(B)(iii), we also requested comment and information on whether a standard other than the presence of a signal of a certain strength should be used to ensure that a household can receive a high-quality picture using antennas of reasonable cost and installation. Specifically, we asked if the inherent assumptions regarding DTV antenna receiving systems should be modified or extended insofar as they

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[44] *See* OET Bulletin 69, "Longley-Rice Methodology for Evaluating TV Coverage and Interference" (February 6, 2004), at 6 Table 4; *see also* 47 C.F.R. § 73.699.

[45] *Id.* at 9.

relate to the proper determination of whether households are unserved by adequate broadcast DTV network signals and are thus eligible to receive distant DTV network signals from a satellite service provider. We requested that commenting parties provide information on the types of antennas that are in use currently, or soon to be available for outdoor or indoor residential use, including technical specifications (*e.g.*, size, gain, beamwidth) and how those factors affect cost and deployment. Further, we requested information on the availability and cost of various devices that can be used to aim these antennas (*e.g.*, rotors) toward DTV transmitters. In this regard, we requested comment on how the addition of a rotor would affect the size of an antenna system and thus the ability of consumers to mount an antenna indoors. We asked that commenting parties provide an evaluation of whether the use of an indoor antenna with or without a rotor would provide similar performance to that expected based on the Commission's assumed planning factors.

24. *Inquiry Record.* The parties commenting in the *Inquiry* who represent broadcast and consumer electronics interests generally state that the Commission should continue to determine whether a household is unserved based on the assumed planning factors, including the use of an outdoor stationary antenna mounted at a height of 9 meters. For example, the NAB states that broadcasters have built transmission systems based on the Commission's standards and it would be unfair to now assume that viewers will use indoor antennas.[46] In a statement attached to the NAB's comments, the engineering firm of Meintel, Sgrignoli, and Wallace (MSW) argue that the planning factors for the DTV receive antenna setup are reasonable based on moderately priced equipment that is readily available to consumers in the marketplace.[47] The Network Affiliates argue that it would be inappropriate to penalize local TV stations for consumers who are only willing to install an indoor antenna when the consumer is willing to take additional, necessary steps to obtain adequate satellite reception.[48] Thus, in the Network Affiliates' view, there is no basis for modifying the inherent assumptions regarding DTV antenna receiving systems in the DTV planning factors.[49] EchoStar and Paul Robinson, the General Manager of Robinson Telephone, take a different position, arguing that the antenna planning factors should be revised to take into account indoor antennas, with EchoStar adding that the lack of rotation capability in outdoor antennas should also be considered.[50]

25. Looking first at the record on antenna performance, commenting parties representing the interests of broadcasters and the consumer electronics industry submit that reasonably priced antennas that exceed the gain and front-to-back ratios assumed in the planning factors are readily available.[51] The Network Affiliates argue that the planning factors should consider the TV receiving antenna to be outside on the roof or adjacent to the house.[52] They further submit that the antenna should be considered oriented to the desired signal, and if the desired stations are not located in the same direction, then the antenna should be considered orientable in the direction of the desired signal(s).[53] The Network Affiliates submit

[46] NAB comments at 18-19.

[47] NAB comments, Attachment 1 (engineering statement of MSW) at 3.

[48] Network Affiliates comments at 34.

[49] *Id.* at 34-35.

[50] EchoStar comments at 6-8; Robinson Telephone comments, *passim.*

[51] Network Affiliates comments at 29-32; NAB comments at 35-43; MSTV comments, Attachment (Engineering Statement of Louis Robert du Treil, Jr. of dLR at 5-6; *see also* ATI Technologies comments, *passim.*

[52] Network Affiliates comments at 34.

[53] *Id.*

that the equipment for a high quality outdoor antenna receiving system, including an eight-way bowtie-with-screen antenna and a rotor with remote control can be purchased for approximately $100.[54]

26. Jules Cohen, in an engineering appendix to the Network Affiliates comments, states that manufacturers' specified antenna gains vary from averages of 12 dB or more for UHF, mostly about 10 dB for high VHF, and 5-7 dB for low VHF.[55] The NAB and the Network Affiliates submit that the best UHF antenna, considering both performance and value, is an eight-bay bowtie-with-screen antenna.[56] The Network Affiliates state that an FCC study in 1980 determined that this design provides an average gain of 13.4 dB.[57] They also state that antennas with higher average UHF gains are available, although they are slightly more expensive.[58] The consulting engineering firm of du Treil, Lundin & Rackley (dLR) (in an attachment to MSTV's comments), the Network Affiliates and Viamorph each compiled data from several leading manufacturers of consumer television antennas.[59] Their compilations show, in part, that Channel Master offers an eight-bay bowtie-with-screen UHF antenna, Model No. 4228, with an average gain of 12.0 dB; Winegard offers a UHF antenna designed for deep fringe areas, Model PR-9032, with a gain of 15.6 dB; and Antennas Direct offers a long-range UHF antenna, Model 91XG, with a gain of 16.7 dB.[60] The Network Affiliates indicate that the Channel Master 4228 retails for $38.99 from Solid Signal (solidsignal.com); Winegard's PR-9032 retails for $34.99 from Solid Signal; and Antenna Direct's Model 91XG sells for $79 (antennasdirect.com).[61] Based on this information, the Network Affiliates submit that the Commission's DTV planning factor of 10 dB for UHF antenna gain is very conservative and can easily be achieved with readily available consumer antennas.[62]

27. The Network Affiliates submit that the most recent study of VHF antennas of which they are aware was conducted by the Institute for Telecommunications Sciences (ITS), an agency of the Department of Commerce, in 1979. That study indicated that the average gain of an antenna for low VHF use was 4.43 dB and for high VHF band use was 8.43 dB. The Network Affiliates note that these gain values exceed the DTV planning factor gain values of 4 dB and 6 dB, respectively.[63] The Network Affiliates also state that currently there are a number of VHF antennas on the market that exceed the gain assumed in the DTV planning factors. They submit that these include the Antennacraft Model CS 1100,

[54] *Id.* at 35.

[55] Network Affiliates comments, Appendix (Engineering Statement of Jules Cohen) at 2.

[56] Network Affiliates comments at 18 and 35; NAB comments at 27-28.

[57] Network Affiliates comments at 18. The Network Affiliates further note that the Electronics Technicians Association, a group whose members install and work in the field with antennas on a day-to-day basis, stated in its comments in the Commission's proceeding in CS Docket No. 98-201 that the eight-bay and four-bay bowtie-with-screen antennas are the conventional UHF antennas for fringe rural areas. *Id.* (citing CS Docket No. 98-201, Electronics Technicians Association, International, Inc. (ETA) Comments at 23).

[58] *Id.* at 18-19.

[59] *Id.* at 19; see also MSTV comments, Attachment (Engineering Statement of dLR) at 6 (Table 2); Viamorph comments at 1-2.

[60] Network Affiliates comments at 19.

[61] *Id.* at 19 n.51.

[62] *Id.* at 19.

[63] *Id.* at 19-20.

with an average gain in the low VHF band of 6.9 dB and an average gain in the high VHF band of 9.6 dB; the Channel Master Model No. 3610, with an average gain in the low VHF band of 5.8 dB and an average gain in the high VHF band of 11.4 dB; and the Winegard Model HD4053P, with a gain in the low VHF band between 5.9 and 6.6 dB and in the high VHF band of between 9.6 and 11.4 dB.[64] The Network Affiliates state that the Antennacraft CS 1100 has a list price of $96.08 (antennacraft-tpd.com) and that Winegard's HD4053P retails for $119.99 from Solid Signal.[65] They submit that with antennas offering these levels of performance, it is apparent that the DTV planning factors of 4 dB gain for low VHF signals and 6 dB for high VHF signals are also very conservative and can easily be achieved with readily available consumer VHF antennas. The NAB submits that another option for consumers is the Winegard SquareShooter SS-2000, a small, attractive directional antenna with a preamplifier.[66] The NAB states that while the manufacturer states that the antenna alone has a gain of 4.5 dB at UHF (below the planning factor assumption), the gain of combined setup with the preamplifier far exceeds the planning factors. It submits that the SquareShooter 2000 is available for about $98.99 from Solid Signal.[67]

28. The Network Affiliates further submit that although combination VHF/UHF antennas do not generally perform as well as separate VHF and UHF antennas, there are consumer models available that exceed the assumed gains in the DTV planning factors. For example, they state that Winegard's Model D7084P has gain of from 6.2 dB to 7.6 dB in the low VHF band, from 10.8 dB to 12.0 dB in the high VHF band, and from 11.8 dB to 14.6 dB in the UHF band and that Antennacraft's Model HD1850 has an average gain of 6.2 dB in the low VHF band, 10.7 dB in the high VHF band, and 10.0 dB in the UHF band.[68] The Network Affiliates indicate that Winegard's HD7084 retails for $127.99 from Solid Signal and Antennacraft's HD1850 has a list price of 174.97.[69] They further note that even Channel Master's eight-bay bowtie-with-screen UHF antenna, Model No. 4228, has been measured by an independent engineering firm, Dielectric Communications, to possess an average gain of approximately 3.0 dB in the low VHF band, approximately 9.0 dB in the high VHF band, and approximately 15.0 dB in the UHF band (which exceeds the manufacturer's own specifications) and that it retails for $38.99 from Solid Signal.[70]

29. The Network Affiliates state that such high-gain antennas are not appropriate for all receiving locations and that where signal strength is already adequate or nearly adequate, such a high-gain antenna could overload a receiver. They note that for those circumstances antenna manufacturers produce smaller antennas with less gain. They point out that CEA, in conjunction with Decisionmark, has established a website, AntennaWeb.org, that is designed to assist consumers in selecting an appropriate outdoor receiving antenna. The Network Affiliates submit that even if the gain of an antenna is less than the gain assumed in the planning factors, that does not mean that the planning factors are defective, because at locations where those antennas are appropriate the ambient signal strength will already exceed the thresholds set forth in the planning factors.[71]

[64] *Id.* at 20.

[65] *Id.* at 20 n.53 (pricing information for Channel Master No. 3610 not available).

[66] NAB comments at 22.

[67] *Id.* at 22 and Attachment 1 (Engineering Statement of MSW) at 16.

[68] Network Affiliates comments at 20.

[69] *Id.* at 20, n.54.

[70] *Id.* at 20-21 and n.55.

[71] *Id.* at 21.

30. The Network Affiliates observe that, although it is not an element affecting the digital signal strength standards, the Commission did assume that TV receiving antennas would have a directional gain pattern in order to discriminate against off-axis undesired stations and thereby ameliorate interference.[72] They note that the ATSC recommends the use of a directional gain antenna to enhance receiver performance with respect to multipath: "[A]n antenna with a directional pattern that gives only a few dB reduction in a specific multipath reflection can dramatically improve the equalizer's performance. Such modest directional performance can be achieved with antennas of consumer-friendly size, especially at UHF."[73] The DTV planning factors account for this directionalization in the assumed front-to-back ratios of 10 dB for low VHF, 12 dB for high VHF, and 14 dB for UHF. The Network Affiliates indicate that it is common for readily available consumer antennas to meet or exceed these assumed front-to-back ratios. They state that, of the antennas mentioned above, the front-to-back ratio of Channel Master's eight-bay bowtie-with-screen UHF Model No. 4228 exceeds 19 dB at all UHF frequencies and is 24 dB at channel 43. Similarly, the front-to-back ratio of Winegard's UHF Model PR-9032 is 14 dB at Channel 14 and 20 dB at both channel 32 and channel 50. The Network Affiliates state that commonly available VHF antennas also appear to easily exceed the assumed front-to-back ratios for the low and high VHF bands. They state that Antennacraft's Model CS 1100 has a front-to-back ratio of 19.4 dB in the low VHF band and 17.6 dB in the high VHF band; and that the front-to-back ratio of Winegard's VHF Model HD4053P is 17 dB or greater across both the low and high VHF bands.[74]

31. The Network Affiliates state that VHF/UHF combination antennas also greatly exceed the assumed front-to-back ratios for the low and high VHF bands and meet the assumed ratios for the UHF band. They indicate that the front-to-back ratio of Winegard's VHF/UHF combination antenna Model HD7084P is 20 dB or greater in the low VHF band, 15 dB or greater in the high VHF band, and is 11 dB at channel 14 and 20 dB at both channel 32 and channel 50. They state that the front-to-back ratio of Antennacraft's VHF/UHF combination antenna, Model HD1850, is 20.2 dB in the low VHF band, 17.3 dB in the high VHF band, and 13.7 dB in the UHF band.[75]

32. Jules Cohen, MSW, the NAB, and the Network Affiliates submit that in addition to selecting antenna with performance criteria that meet their needs, consumers can be expected to exert the same efforts to receive DTV signals that they have always been expected to exert to receive analog signals. They state that this may include the use of a rotor to properly orient the antenna to receive different signals if needed and, in fringe areas where signal strength is known to be weak, use of a low-noise amplifier (LNA) or "pre-amplifier."[76] Jules Cohen, dLR, MSW, and the Network Affiliates report that there are many current offerings of moderately priced LNAs with signal amplification available in values between 18-30 dB and with noise figure values between 3-5 dB.[77] For example, they observe that Winegard currently offers 16 different LNAs with gains ranging from 17 dB to 29 dB and note that the Winegard Model AP-8275 provides an average gain of 29 dB for VHF and 28 dB for UHF with an

[72] *Id.* at 21-22.

[73] *Id.* at 22 (quoting *ATSC Recommended Practice: Receiver Performance Guidelines*, Doc A/74 (June 18, 2004) at 24).

[74] *Id.* at 22-23.

[75] *Id.* at 23.

[76] *Id.* at 23-24; NAB comments at 16-23.

[77] NAB comments, Attachment 1 (Engineering Statement of MSW) at 17-18; see also Network Affiliates comments at 25-26 and Appendix (Engineering Statement of Jules Cohen) at 3.

internal noise figure of only 2.9 dB and 2.8 dB in those respective bands, with a retail price of $77.99 from Solid Signal.[78] Similarly, the Channel Master 7777 has an average gain of 23 dB for VHF and 26 dB for UHF with internal noise figures of 2.8 VHF and 2.0 dB for those respective bands, and it retails for $56.99 from Solid Signal.[79] Also, Antennacraft offers an LNA with adjustable gain to prevent overload, Model 10G212, that provides an average gain of 30 dB for both VHF and UHF with a noise figure of less than 4.0 dB for VHF and less than 3.5 dB for UHF, with a list price of $33.63.[80] The Network Affiliates identify Blonder Tongue and Advanced Receiver Research as additional LNA manufacturers. MSW submits that the ready availability of these preamplifiers provides a substantial "cushion" against the possibility of any losses not specifically accounted for in the planning factors.[81] Jules Cohen states that a conservative choice of parameters to illustrate the advantage of using a pre-amplifier at the antenna would be: amplifier noise figure 5 dB, amplifier gain 20 dB and receiver noise figure of 12 dB.[82] He further states that the resulting system noise figure would be 5.2 dB, which considering that the system noise figures in the planning factors are 10 dB for VHF and 7 dB for UHF, would provide an extra margin to minimize the impact of system mismatches.[83]

33. With regard to proper orientation of antennas, EchoStar contends that even households with outdoor antennas often do not have rotating antennas or have a practicable means of re-pointing their antennas "on the fly" to achieve optimum reception for every broadcast station in the market.[84] It states that in some markets not all of the network stations may be transmitting from the same site, so that there may be no single "optimal" pointing solution. EchoStar further contends that even households with antennas that are capable of rotating generally do not have the ability to adjust the orientation of their antennas "on the fly" so that for most purposes the antenna is non-rotating. In a statement appended to EchoStar's comments, the consulting engineering firm of Hammett & Edison, Inc. (H&E) claims a worst case loss scenario of 14 dB for a high-performance (*i.e.*, high-gain) antenna at UHF.[85] H&E further states that it conducted a study using the Terrain Integrated Rough-Earth Model (TIREM) that found that the majority of all households in the United States are able to receive at least two analog TV stations of Grade B intensity and that, of those households, the majority receive at least one from an angle that differs by greater than 25° from another station.[86] As a result, it contends that almost all households will have impaired reception of at least one station. EchoStar believes that this analysis suggests that signal strength loss from the lack of a rotating antenna can be significant and should therefore be taken into account.[87] It states that one way to do so would be to conduct further study to determine the "average"

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[78] Network Affiliates comments at 25 and n.70.

[79] *Id.* at 25 and n.71.

[80] *Id.* at 25-26.

[81] NAB comments at 23, and Attachment 1 (Engineering Statement of MSW) at 18.

[82] Network Affiliates comments, Appendix (Engineering Statement of Jules Cohen) at 3.

[83] *Id.*

[84] EchoStar comments at 7-8.

[85] *Id.*, Attachment A (Engineering Statement of H&E) at 3 (worst case scenarios are 10, 12 and 14 dB for low VHF, high VHF and UHF, respectively). H&E does not provide a value for average signal loss from mispointing,

[86] *Id.*

[87] EchoStar comments at 7-8.

signal loss caused by the lack of a rotating antenna and to subtract that amount from the measured signal strength before comparing it to the Commission's signal strength standards.

34. On the other hand, dLR, the Network Affiliates, and the NAB argue that the Commission should continue to assume that DTV antennas are oriented towards the desired signal, and if the desired stations are not located in the same direction, that that antenna will be orientable in the direction of the desired signal.[88] They argue that this assumption remains appropriate given the availability of reasonably priced antennas and rotors as described above. The Network Affiliates submit that the Electronics Technicians Association (ETA) showed in the Commission's proceeding in CS Docket No. 98-201 that the majority of home antenna systems in Putnam County, Indiana, a location representative of the outer reaches of the service areas of several broadcast stations, contain a rotor (in addition to a LNA) and that this is true even though homeowners in Putnam County can receive network programming from each of the four major networks from stations all located in Indianapolis.[89] They argue that consumers can and will obtain rotors when they believe that they need them. They note statements by the ETA that rotors are economical ($60-$75) and do not require constant rotation and that "to circumvent the intent of the SHVA because the homeowner prefers not to invest in a rotor where needed is not right."[90] The NAB argues that it would be discriminatory to assume that a DBS household's over-the-air antenna is improperly oriented when that same household's satellite antenna must be precisely oriented towards the satellite to get any service at all.[91] It notes that the DTV transition has been premised on the assumption that viewers will use properly oriented antennas to receive digital TV signals.[92]

35. The NAB states that, in most instances consumers can use a single, fixed antenna, because the TV transmitters in many markets are co-located. In such cases, there will be no need for a rotor. It states that in markets where TV towers are located at different sites, local electronics installers sometimes offer a special antenna designed to receive signals from two different directions, again without the need for a rotor. And NAB states that for those instances which differ from the situations just discussed, consumers can acquire, at a modest cost, a rotor that enables a rooftop antenna to be oriented to achieve the best signal from a particular station.[93]

36. With regard to the availability of antenna rotors, the engineering statements and comments submitted by dLR and the Network Affiliates point out that many models, such as those sold by Channel Master, Antennacraft, Delhi (formerly Jerrold), and Radio Shack, are readily available. The comments also indicate that some of these rotors are available with a remote control so that the viewer can properly orient the antenna conveniently, from the couch or other location.[94] The NAB and the Network Affiliates submit that prices for rotors range from $68.99 for a Channel Master unit with remote control (CM 9521A, available from Solid Signal) to $94.88 for an Antennacraft model (available at antennacraft-

[88] MSTV comments at 2 and Attachment (Engineering Statement of dLR) at 9; Network Affiliates comments at 34-35; NAB comments at 19-20 and Att.1 (Engineering Statement of MSW) at 13-15.

[89] Network Affiliates comments at 27.

[90] *Id.* (quoting CS Docket No. 98-201, ETA Comments, *supra* note 57, at 6).

[91] NAB comments at 19-20.

[92] *See* NAB comments at 25-26.

[93] *Id.* at 20.

[94] MSTV comments, Attachment (Engineering Statement of dLR) at 9; Network Affiliates comments at 27 and Appendix (Engineering Statement of Jules Cohen), Exhibit 3 (Rotors).

tpd.com).[95] Viamorph, a manufacturer and licensor of antenna technologies, states that its research indicates that aiming a directional antenna is more difficult for digital TV signals than for analog TV signals and that a fixed digital TV antenna may not be a viable solution for many consumers.[96] Viamorph submits that it is introducing a new class of antennas which it calls DiSA (Digital Smart Antenna) that automatically adjust their electrical shapes in response to changes in environment and signal conditions so as to maintain optimal performance. We also observe that CEA has issued a voluntary industry standard (CE-909) for TV antennas that automatically adjust their receive pattern to increase their gain in specific directions to receive individual signals. We have examined an antenna system constructed to this standard, the DTA 5000 (manufactured by DX Antenna Co.) which was small enough to be used indoors as well as outdoors, and have observed that it does appear to provide significantly improved reception of individual digital TV signals.

37. With regard to indoor antennas, EchoStar states that, because structures located within the line of sight between a TV transmitter and receiving antenna can block or weaken the strength of received signals, an outdoor antenna will generally allow a stronger signal to be received than will an indoor antenna.[97] It argues that households in which the antenna is placed indoors will generally need an antenna with greater gain than will a household in which the antenna is placed outdoors. EchoStar argues, however, that because of limitations on the physical dimensions of indoor antennas, they have always had less gain than typical outdoor antennas. EchoStar notes that a review by H&E of the existing literature published as recently as 2005 and as far back as 1959 shows that indoor antenna gain is consistently about 9 dB or more below the values for outdoor antennas.[98] EchoStar also submits that signal loss due to building penetration before it reaches an indoor antenna can be as great as 30 dB for VHF signals in a highly populated area like New York City, but this will vary depending on which floor of a building the indoor antenna is located.[99] EchoStar argues that these factors mean that households relying on an indoor antenna for DTV reception are at a considerable disadvantage. It further argues that an outdoor antenna is not practical for many households, particularly those located in apartment buildings and that for these reasons the DTV signal strength standards should take into account indoor antenna use.[100] Paul Robinson similarly argues that in a dense urban area most people may be living in multi-story apartment buildings

[95] NAB comments at 20; Network Affiliates comments at 27-28.

[96] Viamorph comments at 2-4. Viamorph indicates that its DiSA™ antenna is amenable to indoor and outdoor mounting, with the current standard model consisting of a flat, rectangular package about 60 cm by 40 cm (approximately 23 inches by 16 inches) on a side and less than two inches (*i.e.*, about 5 cm) thick.

[97] EchoStar comments at 6. EchoStar (Comments, Attachment A (Engineering Statement of H&E) at 4 and 14-15) points to a study published by the Institute for Telecommunication Sciences in 1979 (FizGerrel, R.G.. *et al.*, "Television Receiving Antenna System Component Measurements," NTIA Report 79-22, June 1979) and to more recent data published by Dielectric Communications (Kerry W. Cozad, "Measured Performance Parameters for Receive Antennas Used in DTV Reception," *Proceedings of the NAB Engineering Conference*, 2005 (Cozad Study)).

[98] EchoStar comments at 6-7. H&E indicates that studies show that indoor antennas typically provide about 8 dB, 10 dB, and 9 dB less gain than outdoor antennas in the low VHF, high VHF, and UHF bands, respectively. EchoStar comments, Att. A (Engineering Statement of H&E) at 4.

[99] EchoStar comments at 7.

[100] EchoStar comments at 6-7.

or in condominium complexes and may be unable to install an external antenna.[101] He urges that the planning factors should take these situations into account.

38. The NAB agrees that indoor antennas provide inferior reception capability to outdoor antennas.[102] In this regard, it observes that indoor antennas are often non-directional and more prone to interference due to being mounted at lower heights and behind wall(s) thus reducing the ambient field strength available to the antenna.[103] NAB also states that indoor antennas are usually nondirectional and therefore more prone to problems from both multipath and interference and are more easily affected by the proximity to viewers whose movement may contribute to altering its reception characteristics.[104] The NAB and MSW further state that it is because rooftop antennas are so much better than indoor antennas that households have long used rooftop antennas to achieve reliable over-the-air reception, particularly where the households are at some distance from the TV transmitting tower.[105] The NAB stresses that rural households often rely on small towers - with over-the-air antennas considerably higher than rooftop level - to receive a strong signal from stations several dozen miles away. This is in contrast to the case of indoor antennas, for which the NAB indicates that recent tests by Kerry W. Cozad show that some currently available indoor antennas deliver a weaker signal than a reference dipole antenna (*i.e.*, these antennas actually have negative gain).[106] The Network Affiliates point out, however, that some indoor antennas currently available have an average gain of approximately 4 dB and, note that the Silver Sensor, with its short connection wire, does not have the line loss assumed in the planning factors.[107]

39. Contrary to EchoStar, the NAB and the Network Affiliates argue that indoor antennas should not be considered in the DTV signal strength standards.[108] They submit that it would be unfair to broadcasters to assume that viewers will use only indoor (or low-quality outdoor) antennas in determining whether DBS subscribers are eligible to receive retransmitted digital network signals. The NAB states that it is specifically because indoor antennas perform so poorly that they should not be considered for defining DTV service.[109] It further states that introducing an assumption that consumers would use indoor antennas would be contrary to one of the most fundamental assumptions of the Commission's entire DTV planning process, leaving broadcasters in the position of having built a system to Commission specifications that the Commission would not deem as adequate because it is not designed to provide service to indoor antennas.[110] The NAB and MSW also state that, had the Commission assumed use of indoor antennas in the planning the digital TV transition, that process would have been radically different, with stations needing enormously higher power levels to reach indoor antennas 50 to 60 miles away.[111]

[101] Robinson Telephone Company comments at 2.

[102] NAB comments at 16-17.

[103] *Id.* at 17.

[104] *Id.*

[105] *Id.* at 17 and Att.1 (Engineering Statement of MSW) at 11-12.

[106] *Id.* at 17 and Att.1 (Engineering Statement of MSW) at 11; see also *id.* at Att. 2 (Cozad Study, *supra* note 97)).

[107] Network Affiliates reply comments at 6.

[108] *Id*, at 16-19; Network Affiliates comments at 34, 39-40.

[109] NAB reply comments at 3-4 and Att. (Reply Engineering Statement of MSW) at 5-6.

[110] *Id.* at 4.

They add that such higher power levels would have changed the interference calculations. The Network Affiliates similarly argue that it is critical to the Commission's plan to replicate analog TV service areas to presume that households will exert similar efforts to receive DTV signals as they have always been expected to do to receive analog TV signals.[112]

40. *Evaluation.* After considering the above information, in response to Section 339(c)(1)(B)(iii) we conclude that the current DTV planning factor assumptions for antenna gain, orientation, and placement remain appropriate and should not be altered for the reasons discussed below. Following from that conclusion, we also find that the current signal strength standard for determining whether a household can receive a high-quality picture using antennas of reasonable cost and ease of installation remains satisfactory and that a different standard is not needed. With respect to Section 339(c)(1)(B)(i), we also specifically conclude that the digital television signal strength standards in the Commission's rules should not be modified to account for the fact that an antenna can be mounted on a roof or placed within a home and can be fixed or capable of rotating.

41. The record on the performance capabilities and availability of antenna receiving equipment indicates that there are a very large number of options for antennas that meet or exceed the gain and front-to-back ratio capabilities assumed in the planning factors. In particular, we observe that antennas that provide gain of 7 dB, 11 dB, and 14 dB or more and front-to-back ratios of 19 dB, 17 dB, and 20 dB in the low VHF, high VHF, and UHF bands respectively are readily available in a variety of models and at a range of affordable prices, *i.e.*, from about $35 to about $100. These capabilities compare favorably to the respective planning factors gain values of 4 dB, 6 dB, and 10 dB and front-to-back ratios of 10 dB, 12 dB, and 14 dB by a fair margin (these performance levels exceed the gain standards by 3 dB, 5 dB, and 4 dB and the front-to-back ratio standards by 9 dB, 5 dB, and 6 dB, respectively). In cases where additional margin in the received signal-to-noise ratio is needed, there are numerous models of low-noise amplifiers available. Similarly, we observe that there is a wide variety of models of antenna rotor devices available, including units with remote controls, at reasonable prices. As the Network Affiliates point out, the Commission has long recommended that households in outlying or difficult reception areas use equipment and mounting locations appropriate to their needs. This equipment can include separate UHF and VHF antennas, which generally provide better performance than a combination UHF/VHF antenna at little or no additional cost. Our own review of the websites of various TV receive system retailers also indicates that products with lower performance levels and prices that can meet many households digital TV receive system needs are readily available. Thus, it is clear that the availability of digital TV receive systems that meet or exceed the antenna performance planning factors is not a constraint on viewers ability to receive signals under the current noise-limited DTV field strength signal intensity standards. The parties commenting in our *Inquiry* did not specifically address the issue of ease of antenna installation. However, based on the experience of the Commission and its staff over many years we do not believe that ease of installation is generally a concern for households in installing the types of antenna needed for use with over-the-air DTV service. Those antennas are essentially of the same design and mounting configuration as those that have been used for analog TV service (antenna design depends on the desired frequency, gain, and front-to-back ratio characteristics, but not on the modulation type, *e.g.*, analog or digital, of the signals to be received). TV antennas can in almost all cases be installed by a household resident or, if the resident desires, a professional installer for a modest charge.

42. We recognize that in some situations the transmitters of digital TV signals that households may desire to view are located in directions that vary by more than the 25° of main beam reception capability provided by typical TV antennas. In such cases the households need either a multiple direction

[111] *Id.* at 18-19 and Att. 1 (Engineering Statement of MSW) at 3-4.

[112] Network Affiliates comments at v, 13-15.

antenna system or an antenna with a rotor that allows the single antenna to be re-oriented in the direction of the desired signal. We find that the signal strength standards do not need to be modified to account for situations where households need to be able to receive signals from multiple directions. We agree with dLR, the Network Affiliates, and the NAB that the digital TV planning model should continue to assume that a) digital TV antennas are oriented towards the desired station and b) if the stations that a household desires to view are not all located in the same direction, then the household employ an antenna that can be re-oriented in the proper direction to receive any such desired station at any given time. As supported by the pattern of antenna rotor use in Putnam County, Indiana that is described in the record of our *Inquiry*, we conclude that consumers will obtain and use rotors if they need them. Likewise, in the many instances where households view signals radiating from one particular direction only, we conclude that those households would not need a rotor and therefore would not install one. We recognize EchoStar's point that a large number of households might be able to better receive signals from stations transmitting from different directions, often from neighboring markets, if they used a rotor. We believe, however, that it is best left to individual households to determine whether signals emanating from different directions are sufficiently desirable to view and, thus, whether to install a rotor to enable their reception. In any case, where a rotor could assist in the reception of television signals for whatever reason, consumers are able now to obtain them readily at affordable prices. We also conclude that it would unnecessarily penalize broadcasters and distort the digital TV service planning model to reduce the assumed available DTV field strength by some factor based on a households' use of a rotor as suggested by EchoStar. We do not recommend such action.

43. We also find that it would not be appropriate to account for the use of indoor antennas in the DTV field strength signal standards for purposes of determining eligibility for reception of distant network signals. As observed by the commenting parties, the strength of signals available for indoor reception is lower due to signal attenuation caused by walls and other structural features and, in most cases, lower antenna height available indoors. The amount of signal attenuation indoors will depend on the material used in a building's construction and where the antenna is located within the building. In addition, the smaller antenna designs that are suitable for indoor use provide less gain than their outdoor counterparts. The differences in the indoor and outdoor reception conditions mean that service will be receivable in many areas with an outdoor antenna but not with an indoor antenna. We believe that it would be impractical to attempt to account for indoor reception conditions in the DTV planning factors. As NAB and MSW observe, the technical standards for the digital television service were established assuming use of outdoor antennas at 9 meters/30 feet height above ground and with the gain set forth in the planning factors. If DTV service were instead based on consideration of indoor reception, then the power levels needed to replicate stations' analog service at distances of 55-60 miles or greater would be substantially higher. For example, if the antenna difference were assumed to be -9 dB, as suggested by EchoStar and H&E, for indoor antennas and building penetration loss were assumed to be a conservative 21 dB, then stations would need to transmit signals with an additional 30 dB of power, or 1000 times the power now authorized for DTV stations.[113] Such power levels are not practical as they would greatly increase the potential for interference between stations and pose power costs for stations that would likely be so high as to threaten the economic viability of many stations. In addition, as discussed more fully below in the section on the digital television measurement procedure, it is not practical or reasonable to specify an indoor reception situation as the signal level that is available indoors will vary significantly at different locations within a residence. For example, the signal level available near an unobstructed window is likely to be higher than that which is available in a basement or an interior room with masonry walls.

[113] A 30 dB power increase would mean that a station operating at 1 MW DTV power would need to operate with 1000 MW, an enormously high power level that is not achievable by currently available TV transmitters.

44. We therefore believe that the current DTV service and operating model that allows stations to replicate their analog service areas based on similar assumptions, *i.e.*, service to outdoor antennas at 9 meters, remains the most appropriate plan for this service. As with analog TV, digital TV signals are receivable at many locations with an indoor antenna. As the distance between the DTV transmitter and receive locations increases, the received signal strength decreases and the opportunities for indoor reception decrease in the same manner as for analog service. We also believe that it would be impracticable to establish a regime whereby households with indoor antennas are subject to different signal strength standards than those with outdoor antennas. The difficulty would arise in setting and applying standards for situations in which a household could not use an outdoor antenna.

45. We recognize that there are instances such as those in which households are located in apartment buildings and condominium complexes where viewers may be unable to use an outdoor antenna. However, we find that commenting parties representing broadcast interests make a compelling point in their observation that satellite dishes likewise can not provide service indoors to such households. We anticipate that if a household were able to install a satellite dish outdoors, it could, in some instances, co-locate an effective broadcast receive antenna with that dish.

2. Receiver Performance

46. At the other end of a household's TV receiving system path is the television receiver. This device receives the broadband electric energy that is taken from the air by the antenna and conveyed to it by the downlead connecting wire, selects the channel desired by the viewer, and processes the information on that channel to provide digital television and other services to the consumer. The desired channel is selected by the receiver's tuner section and then demodulated to produce the 19.4 mbps ATSC digital bitstream that carries the program and other information provided on the signal by the broadcast TV station. The performance of a digital television receiver with respect to reception of service for purposes of SHVERA eligibility determinations depends on its noise figure, signal-to-noise (S/N) ratio, and adaptive equalizer capabilities.[114] Noise figure is a measure of the level of noise generated internally within the device.[115] Signal-to-noise ratio is a measure of the receiver's ability to discern a desired digital television signal from other energy (noise) that is present in the signal's channel. The adaptive equalizer is a feature of a digital television receiver's tuner section that determines its ability to handle reflections of the desired signal. These reflections are also known as multipath signals and can be observed on analog television pictures as "ghosts."[116] The noise figure and S/N measures are included in the DTV planning factors as indicated above. The planning factors assume use of a receiver that has noise figure levels of not more than 10 dB in the low and high VHF bands and 7 dB in the UHF band and that can provide service when the received S/N ratio is 15 dB or more. If the representative values of actual receiver noise figures and S/N ratios are different from those of the planning factors it could affect the minimum field strength needed for service. If the sum of these factors is greater or lower than that assumed in the planning factors, a higher field or lower field strength, respectively, would be needed for service. Adaptive equalizer performance is not included in the planning factors because it was assumed that the receiver designs for this feature would adequately handle multipath signals. However, adaptive equalizer performance did become of concern more recently when it was determined that multipath was a

[114] There are other receiver performance factors such as selectivity, overload, and shielding against signal ingress that affect its ability to reject unwanted signals. These factors are less important in the context of this Report.

[115] All electronic devices generate some amount of internal noise, the level of which depends on their design and the components used in their construction.

[116] With digital television service, if a receiver's adaptive equalizer is unable to handle multipath the result is no service.

larger challenge than initially anticipated and that a high level of ability to cope with multipath signals is important to reception of DTV signals.

47. In the *Inquiry*, as directed by Section 339(c)(1)(B)(v) we requested comment and information on whether there is a wide variation in the ability of reasonably priced consumer digital television sets to receive over-the-air signals, so that at given signal strengths some sets are able to display high-quality pictures while other sets cannot, and if so, whether this variation is related to the price of the television set. As further directed by Section 339(c)(1)(B)(v), we also requested comment on whether such variation should be factored into setting a standard for determining whether a household is unserved by an adequate digital signal. In considering these questions, we note that the nature of digital television operation is such that a receiver will provide a high-quality picture (consistent with its display capabilities) at all signal levels at or above its threshold of service.[117] When the received signal/field strength falls below the minimum service threshold there is a very sudden loss of service that occurs over a signal strength change of less than 1 dB. This sudden loss of picture service, which first appears as blocking and freezing of portions of the image, is called the DTV "cliff effect." This operating characteristic is in contrast to analog TV service in which picture quality degrades gradually as signal strength declines. Thus, we will assume in our evaluation of digital television receiver performance that picture quality remains high at all signal/field strength levels above the minimum threshold needed for service.

48. In the *Inquiry*, we specifically requested that commenting parties provide information regarding the sensitivity of various receivers and their interference rejection capability. We asked that this technical information be accompanied by price data and analysis regarding the correlation between performance and price. Finally, we asked if there are significant differences in digital receiver performance quality and, if so, should those differences be factored into the determination of whether a household is unserved by an adequate digital signal. The Commission's Laboratory staff also undertook a technical measurement study of the performance capabilities of a sample of the digital television receivers currently on the market, looking at noise figure, S/N/ ratio, adaptive equalizer/multipath handling performance, and price.

49. *Inquiry Record.* With regard to DTV receiver noise figure performance, dLR states that it has not independently tested a representative sample of DTV receivers for their noise figure performance and assumed that information would be developed from the Commission's receiver study in this matter.[118] MSW and the NAB submit that while there is little published data about receiver noise figures, consumers can, in any event make the noise figure of a receiver irrelevant by employing an inexpensive preamplifier.[119]

50. Concerning the DTV receiver S/N ratio, dLR states that laboratory measurements by Bouchard, *et al.*, of the Communications Research Center Canada (CRC) in late 2000 (Bouchard study) demonstrate S/N levels consistent with the Commission's assumed value of 15.2 dB for this planning

[117] Digital television receivers are typically designed to provide picture quality at one of several maximum quality levels: standard definition (similar to analog 480i service), enhanced definition (480p or 640p), or high definition (720p or 1080i). The price of receivers generally increases with higher picture quality capability.

[118] MSTV comments, Att. (Engineering Statement of dLR) at 8.

[119] NAB comments at 22, Att. 1 (Engineering Statement of MSW) at 17.

factor.[120] The measurements in this study were conducted on a sample of six DTV receivers manufactured in the period 1999-2000. For a weak desired signal, the study found a S/N range or 15.3 dB to 17.8 dB, with a median S/N of 15.6 dB. The five best out of the six had a S/N of 15.3 dB to 16.6 dB with a median S/N of 15.4 dB.[121] dLR further states that laboratory measurements by the CRC on a Zenith fifth generation DTV receiver in September 2003 also show S/N measurement results that are consistent with the Commission's planning factor value.[122] dLR submits that these results show a measured S/N of 15.9 dB in the presence of a weak signal level, which is within .7 dB of the planning factor value and indicates that the latest generation of DTV receivers will perform in line with those of earlier manufacture.

51. EchoStar argues that the DTV signal strength standards should be revised upwards because the signal sensitivities of the current generation of consumer DTV receivers can be significantly worse than the signal sensitivities, *i.e.*, S/N ratio plus noise figure, assumed in the planning factors for UHF and VHF reception.[123] It argues that as a result of this difference in performance versus assumption, many consumer DTV sets may not be able to display a DTV picture even when the signal strength meets the Commission's standards. In support of EchoStar's position, H&E evaluated five DTV receivers for sensitivity in comparison to the DTV planning factor values.[124] H&E submits that its results show that the measured sensitivities range as much as 6.6 dB higher than the planning factor values of -81.4 dBm and -84.4 dBm, that the receivers differed in sensitivity by 2-6 dB under favorable field conditions, *e.g.*, no multipath signals, and the average receiver in its study was 2.6 dB less sensitive than the planning factor value. In its reply comments, ATI points out that the H&E study considered older receivers that did not conform to the ATSC A/74 receiver performance standards or incorporate current models of VSB demodulators and so it is not surprising that the receivers H&E tested suffer from the shortcomings that the fifth generation of VSB demodulators was designed to resolve.[125]

52. EchoStar and H&E submit that multipath handling capability can affect a digital television receiver's ability to provide service.[126] They state that multipath can be measured and its severity can be expressed as a signal strength penalty caused by the adaptive equalizer in a receiver attempting to compensate for the multipath. H&E states that a receiver's adaptive equalizer, in attempting to compensate for the multipath will increase the system's noise level at the frequencies of compensation. H&E submits that at a good receiver location with little multipath, the adaptive equalizer tap energy might be about -10 dB, corresponding to a white noise penalty of less than 0.5 dB and that at a poor

[120] MSTV comments, Att. (Engineering Statement of dLR) at 8 and n.3 (citing Bouchard, Pierre, *et al.*, "Digital Television Test Results – Phase I," Communications Research Centre (Ottawa, Canada), *CRC Report No. CRC-RP-2000-11*, November 2000).

[121] The worst performing receiver in the Bouchard study was the oldest measured unit.

[122] MSTV comments, Att. (Engineering Statement of dLR) at 8-9 and n.4 (citing "Results of the Laboratory Evaluation of Zenith 5th Generation VSB Television Receiver for Terrestrial Broadcasting," Report Version 1.1, Communications Research Centre Canada, September 2003).

[123] EchoStar comments at 4 and Att. A (Engineering Statement of H&E) at 12-13.

[124] EchoStar comments, Att. A (Engineering Statement of H&E) at 12-13. Three of the receivers in the H&E study were obtained from retailers in May 2005, the fourth was an older model purchased in 2000, and the fifth was a professional ATSC demodulator.

[125] ATI reply comments at 2.

[126] EchoStar comments at 5 and Att. A (Engineering Statement of H&E) at 8-9.